[CLAIMS] **For reissue of U.S. Pat. 6,373,868** (New Page 1 and 10) 3/31/2006

--- The clean version of the entire set of claims 1-15 to replace the original claims 1-9 issued on 4-16-2002 and the pending claims 1-10 for reissue filed on 4-8-2004. It also is to replace the amendments indicated in the letter of "Preliminary Amendment A" filed on 2-25-2005.

[Note] There are two portions in the new claims, i.e., claims 1-9 and claims 10-15. Claim 1 and claim 10 are the two independent claims. Claims 1-9 are used to cover the situation with respect to a beam expanding laser cavity. Claims 10-15 are used to cover the situation with respect to a regular laser cavity. Each of them is very similar to the set of claims 1-9 in Pat. 6,373,868, in which only one independent claim covers these two situations. In other words, now claims 1-9 have been kept almost the same as before, except that the contents related to a regular laser cavity have been taken away. And then new claims 10-15 are added for the situation of the regular laser cavity.

What is claimed is:

1. In a method for configuring a standing-wave cavity arrangement for solid-state lasers in obtaining stable single-mode operation, whereby overcoming the major difficulty with intracavity frequency conversions, typically in frequency doubling caused by the so-called "green problem", comprising the steps of
   (1) constructing a forming means for said cavity, including at least two end mirrors, wherein said cavity is a beam expanding laser cavity;
   (2) constructing a pump head means placed within said cavity for lasing at a fundamental wavelength; comprising the steps of
      A. selecting a solid-state laser medium means;
      B. selecting a pump source means including laser diode bars to provide relevant pumping beams for pumping said laser medium means; and
      C. producing a gain region within said laser medium means by said pump source means;
   (3) constructing a formation of wavelength selectivity with low insertion losses placed within said cavity, wherein the performance parameters of said formation are predetermined whereby to sufficiently and uniquely determine the laser's oscillating frequency and to force the laser to perform a stable single-mode or narrow band operation; and
   (4) selecting an approach for promoting single longitudinal mode operation from the group consisting of
      A. a first approach, comprising
         1) creating said gain region within a narrow area along the optical axis of said cavity and immediately adjacent to one of said end mirrors, and
         2) selecting said formation from the group consisting of
            a) a first formation, built up of a Lyot filter and a one-dimensional beam expander means, and

intensity of said second harmonic radiation and the conversion efficiency.

10. In a method for configuring a standing-wave cavity arrangement for solid-state lasers in obtaining stable single-mode operation, whereby overcoming the major difficulty with intracavity frequency conversions, typically in frequency doubling caused by the so-called "green problem", comprising the steps of
    (1) constructing a forming means for said cavity, including at least two end mirrors, wherein said laser cavity is a regular laser cavity without a beam expander;
    (2) constructing a pump head means placed within said cavity for lasing at a fundamental wavelength; comprising the steps of
        A. selecting a solid-state laser medium means;
        B. selecting a pump source means including laser diode bars to provide relevant pumping beams for pumping said laser medium means; and
        C. producing a gain region within said laser medium means by said pump source means;
    (3) constructing a formation of wavelength selectivity with low insertion losses placed within said cavity, wherein the performance parameters of said formation are predetermined whereby to sufficiently and uniquely determine the laser's oscillating frequency and to force the laser to perform a stable single-mode or narrow band operation; and
    (4) creating said gain region within a narrow area along the optical axis of said cavity and immediately adjacent to one of said end mirrors.

11. In the method of claim 10, said formation including
    (1) a first formation comprising a monochromatic polarizer means; and
    (2) a second formation comprising an etalon.

12. In the method of claim 11, further comprising the steps of
    (1) using a nonlinear crystal means arranged in an optimal condition including phase-matching for intracavity frequency conversion;
    (2) maintaining the bandwidth of said formation to be smaller than the laser longitudinal oscillating mode interval of said cavity, and its free spectral range is larger than the FWHM of lasing bandwidth of the gain medium;
    (3) building said monochromatic polarizer means up of a polarizer and said nonlinear crystal means; and
    (4) selecting said laser cavity from the group including 1) regular standing-wave cavities; 2) V-shaped standing-wave cavities; and 3) L-shaped standing-wave cavities.

Statement of Status/Support for all Changes to the Claims

March 31, 2006

This reissue is a broadening reissue, also is to make the claims more clear, simplify and readable, and to correct some inaccuracy which are caused by that in Pat. 6,373,868 only one single independent claim was used to cover too many different situations and approaches. On the other hand, several amendments also have been made in the specification. All of the drawings are kept exactly the same as before.

Long time ago in 1995 there had been two difficulties for applicant while he wrote the claims for his patent application, now Pat. 6,373,868. The first difficulty was how to avoid the overlapping with the parent patent. The second difficulty was how to use only one independent claim to do so in order to save money due to his very bad financial situation during that time.

In other words, this invention is the kind of root invention. It should have been fully covered by one simple independent claim without any problem if there was no the parent patent. On the other hand, it could be easily claimed by several independent claims in order to avoid the overlapping with the parent patent.

[Fact 1] The subject matter of Pat. 6,373,868 is for solving the well-known so-called "green problem". The subject matter of its parent patent of Pat. 5,515,394 is for solving mode-match pumping. However, the subject matter of Pat. 6,373,868 was been partially disclosed in its parent patent.

[Fact 2] The original patent application of Pat. 6,373,868 included several subject matters in which only one independent pending claim was for U.S. Pat. 6,373,868. The other subject matters have been issued with U.S. Pat. 6,873,639 later.

In view of the above mentioned two difficulties, there have been two issues with the claims in Pat. 6,373,868.

The first issue is that there should have been at least two independent claims to cover several different approaches and situations. One independent claim should be used to cover the situation with a regular laser cavity. The other one should be used to cover the situation with a beam expanding laser cavity. Further, only later has been partially disclosed in the parent patent. And only this part needs some limitation to avoid the overlapping with the parent patent.

[Fact 3] In Pat. 6,373,868 there is only one independent claim, i.e., claim1. In claim 1 (4) two approaches are discovered and specified to realize single longitudinal mode (SLM) operation in order to solve the well-known so-called "green problem". The step (4) A and B of Claim 1 define the first approach and second approach, respectively.
In the first approach, a formation of wavelength selectivity with low insertion losses, i.e., a low resolving-power spectral filter relative to a low frequency-selective loss has been used in cooperation with a pump head with a thin gain zone that leads to promoting single longitudinal mode operation.

The second issue is, therefore, only under the situation with the use of a beam expanding laser cavity it is necessary to have some limitation to avoid the overlapping with the parent patent, rather than under the situation with the use of a regular laser cavity.

Accordingly, in this reissue application, the following procedures have been applied in order to retrieve these two issues in Pat. 6,373,868.

There are two portions in the new claims, i.e., claims 1-9 and claims 10-15. Claim 1 and claim 10 are the two independent claims. Claims 1-9 are used to cover the situation with respect to a beam expanding laser cavity. Claims 10-15 are used to cover the situation with respect to a regular laser cavity. Each of them is very similar to the set of claims 1-9 in Pat. 6,373,868, in which only one independent claim covers these two situations.

In other words, now claims 1-9 have been kept almost the same as before, except that the contents related to a regular laser cavity have been taken away. And then new claims 10-15 are added for the situation of the regular laser cavity.

Further, the following amendment is made in claim 1 (4) in Pat. 6,373,868 for the new claim 1 (4),
Change "eliminating or minimizing the spatial hole-burning effect" to --- promoting single longitudinal mode operation ---.

[Fact 4] It has already been pointed out in claim 1 (1) in Pat. 5,515,394, i.e., the parent patent, that "whereby minimizing or eliminating the spatial hole-burning effect to facilitate single longitudinal mode operation." Therefore, the approach selected in claim 1 (4) in Pat. 6,373,868 is directly for promoting SLM operation. As the further explanation in laser physics in detail, please refer to the following Appendix "More Explanation in Laser Physics for Fact 4".

Moreover, there are two modifications in the second portion of the new claims 10-15. The first one is to get rid of the contents related to the situation with a beam expanding laser cavity. The second modification is that, a limitation from the independent claim is removed to the next succeeding dependent claim.

[Fact 5] In claim 1(4) in Pat. 6,373,868, it is not necessary to stipulate said formation of wavelength selectivity in detail in the first approach to limit its coverage. (Please refer to the above "the second issue".) Accordingly, those specified members for said formation, which are recited in a Markush group, now have been removed from the independent claim into the succeeding dependent claim in the new set of the claims.

In conclusion, there are three amendments in the new claims 1-15. Firstly, the new claims 1-9 have been kept almost the same as before for the beam expanding laser cavity. And then new claims 10-15 are added for the regular laser cavity. Secondly, one limitation in the independent claim 10 is removed into the next dependent claim 11. The third one in new claim 1 is mentioned above in [Fact 4].

APPENDIX

[More Explanation in Laser Physics for Fact 4]

The two approaches in Claim 1 (4) A and B are to directly create a favorable circumstance to promote SLM operation, even though people usually call it as the term of "eliminating or minimizing the spatial hole burning effect" in laser physics.

The real meaning and intention in the first approach in claim 1 (4) A is to create a favorable circumstance to promote SLM operation. In such a circumstance, all possible longitudinal modes have about an equal chance to extract the available gain. That mode which begins to oscillate first wins the "mode-competition" and deprives the others of the gain needed to oscillate, thereby forcing single axial-mode operation. In view of that all of the above sentences is too long to be presented, therefore, people usually use the term of "eliminating or minimizing the spatial hole burning effect" in order to brief it.

Further, what is the physics property for the thin gain region in contact with an end resonator mirror? It is the only narrow area within the laser cavity where is exactly in phase for all possible longitudinal-modes of laser operations. In such a circumstance, all the longitudinal modes have a common spatial node at the surface of the mirror, and access to the same population inversion since in this narrow excited region. The mode with the highest cross section for stimulated emission will oscillate first, saturation the population inversion and reducing the gain of the medium to the threshold gain of this first mode. This modification of the population inversion reduces the gain available to the other longitudinal modes. Other cavity modes with lower cross sections can not reach threshold since they use the same population distribution as the highest gain mode.

As a conclusion, there still exists spatial hole burning, but due to the overlap among many possible standing-wave patterns (or many possible longitudinal modes) within this narrow excited region, spatial hole burning would not cause any problem for SLM operation. Therefore, it should be more precisely to say that: the selected approach in claim 1 (4) is for eliminating or minimizing the favorable condition for multi-mode operation so as to promote SLM operation, rather than to eradicate spatial hole burning.

[What is "Green Problem"]

It had been harassed and frustrated for many world-class scientists and engineers, for almost ten years from 1986 to 1995, to obtain stable continue wave (CW) visible light, typically green light from the new generation laser system, i.e., DPSS lasers. It is that the well-known so-called "green problem". The essential difficulty in solving the "green problem" results from that, there is a persistent obstacle in effectively obtaining single longitudinal mode (SLM) CW operation due to the favorable condition for multi-mode operation in solid-state lasers. The related critical design issues are considered to be extremely tough during that time.

[What is Claimed in My Patent and Its Patentability]

In U.S. Pat. 6,373,868 a favorable condition for SLM operation is created by means of a thin gain region in contact with an end cavity mirror. Then a low resolving-power spectral filter with low loss, such as Lyot filter or low-finesse etalon or the like, is used to realize single axial-mode CW operation and stable intracavity SHG output, whereby overcoming the major difficulty with intracavity frequency conversions, i.e., the well-known so-called "green problem". Such a laser arrangement is universal for all kind of solid-state lasers.

In order to overcome the well-known so-called "green problem", nobody in the prior art has ever suggested and considered the use of a low resolving-power spectral filter relative to a low frequency-selective loss in cooperation with a pump head with a thin gain zone that leads to promoting SLM operation. This is the first approach defined by the step (4) A of Claim 1. Also, nobody in the prior art has ever suggested and considered the use of a spectral filter in cooperation with a beam expander to reduce the insertion losses. This is the second approach defined by the step (4) B of Claim 1 in U.S. Pat. 6,373,868.